Shin Jchi NAKAMURA* & Minoru HAMADA**: **On the seed dispersal of an achlorophyllous orchid, *Galeola septentrionalis***

中村信一*・浜田稔**: 無葉緑ラン，ツチアケビの種子散布について

(Plate III)

A fruit of *Galeola septentrionalis* Reich. fil. (Fig. 1), which accomodates ca. 16,000 anatropous seeds (Fig. 2) laid on paracarpous placentae (Fig. 3 and 4), is bright red and baccate, and remains indehiscent and attached to the inflorescence after ripening. Germination of the seeds and the subsequent growth of the seedlings require the air with weakened O_2-and enhanced CO_2-concentration (Nakamura et al. 1975, Nakamura 1976). The requirements of atmospheric conditions for early development and the structure of the fruit are occasionally associated with endozoochory (Stoutamire 1974 and personal communication).

Hitherto, endozoochorous seed dispersal, particulariy ornithochory is supposed in *Vanilla planifolia* Andr. a species representative of the subtribe Vanillinae to which *Galeola* belongs: In South America, many species of birds peck greedily at the ripe fruit which accomodate the seeds suspended in a leather-brown gruel of sarcocarp. Since the seeds escape digestion owing their hard testa, they are widely scattered with excrement (Beer 1863). Another description (Bouriquet 1943) states: It appears to be favourable for the successful germination, to eliminate a fatty substance from the seed by any organic solvent such as benzine or by the action of enzymes in the intestinal canal of various animals. Certainly, there lives such an animal, probably a bird, in the country of origin, Mexico.

In *G. septentrionalis*, we sometimes meet with the fruit eaten off seemingly by rodents, and discoloured entirely, presumably by the action of polyphenolases. Once we were surprised by a bird which suddenly began flight from a stock of the orchid when we visited it; and found some remnant fruit in undiscoloured, i.e. in fresh condition. A feather was found under these fruits and identified as the thorax down of the eastern turtle-dove

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(*Streptopelia orientalis orientalis* Latham.), one of the most common birds in Japan. Although the connection between the eater and the feather is only inconclusively ascertained, an ornithochorous seed dispersal can be postulated.

But this assumption seems to be hardly compatible with the rareness of this orchid. Moreover, ornithochory as a usual mode of seed dispersal is inconsistent with the fact *in situ* that the fruit can mostly escape from being eaten up by vertebrate(s) and remain hanging on an infructescence till the next autumn, as long as this does not fall down.

The juice squeezed from the completely ripe fruit of *G. septentrionalis* was refractometrically estimated at 15.1% sugar on the average, with the tip offering a higher value than the proximal part. According to Hamada (1939), the juice cryoscopically showed 17.96 atm, i.e. contained 0.801 mol/litre solutes in total. Since both measurements are to be equivalent to each other, the juice may contain 13.7% mono- (presumed mol wt 180.2) and 1.4% disaccharide (presumed mol wt 343.3), if major components of the solute are assumed as a mixture of mono- and disaccharides.

This view is supported by a chromatographic examination (Whatman No. 1 filter paper, triple development by the ascending method with an upper layer of a mixture of 2 volumes ethylacetate, 1 volume pyridine and 2 volumes water as a solvent system). Judging from the loci and intensities of spots after spraying with an ammoniacal solution of $AgNO_3$, 2 kinds of monosaccharide and/or sugar alcohol (glucose, laevulose, mannitol or sorbitol) in plentiful quantities, besides a slight amount of a disaccharide sucrose, are contained in the fruit. In fact, the sarcocarp tastes sweet but a little bitter in the fresh. and delicious in the discoloured condition. That is to say that the ornithochorous trial has not succeeded in this orchid despite sugar preparation of esculent quality and sufficient quantity.

Burgeff (1936) clocked the time necessary to fall from a 155 cm height as a parameter of endurance in the air. The seeds of various orchids (46 spp. and 45 hybrids) offered values (averages of 3 trials each) between 2.3 sec (hybrid of *Laelia tenbrosa* × *Cattleya mendeli*) and 39 sec (*Zeuxine reflexa*) with an extraordinary record 120 sec (*Epipogium nutans*), mostly (37 spp. incl. *Galeola lyndleyana* recorded 7.7 sec and 30 hybrids) longer than 5 sec independently with epiphytic or terrestrial natures. He concluded that the air endurance contributes to the seed dispersal by wind (Burgeff 1936). Seeds

of *G. septentrionalis* and *G. altissima* Reichb. fil., another species of that genus producing dehiscent fruits, needed 3.0±0.05 and 7.4±0.17 sec for a downfall through 155 cm, respectively. Because of the air endurance of seeds and features of their fruit, an anemochorous dispersal is supposed by *G. altissima*, but never by *G. septentrionalis*.

A seedling of *G. septentrionalis* does not contain a spectrophotometrically measurable amount of chlorophyll, possesses no trichome and soon ceases to elongate the radicular end (Fig. 5-8, re). A few of those put forth an axillary shoot (Fig. 6, axs and its subtending leaf f). In most cases, adventitious roots arise under some scaly leaves (Fig. 7 and 8, adr under f). In general a protocorm with these characteristics grows very slowly (Stoutamire 1964). To raise the seedlings shown in Fig. 9 and 10, we had to keep cultures in atmospheres suitable for each developmental stage for about 20 and 70 weeks from the sowing, respectively. Though the required atmosphere progressively approaches normal air following the development of a seedling (Nakamura 1976), even the 46-month-old ones grow only under restricted aeration (Fig. 11). Under restricted aeration (ca. 7% in comparison with a free opening), seedling growth was scarcely suppressed by a desiccation with the relative humidity higher than 10.5% which had been prepared at the start of the vial culture by means of isothermal distillation with H_2SO_4 (data not shown).

Soil atmosphere reveals the values coincident with the condition required for the early development of this orchid and holds moisture sufficient for it (Stiles 1960). The water-repellent surface of scobiform seeds facilitates them to reach a certain depth of soil hydrochorously (Koch 1887, cited by Burgeff 1936). By *G. septentrionalis* the seed coat is water-repellent. Accordingly hydrochorous seed dispersal is most conceivable as a routine mode in this orchid. Endozoochorous dispersal would occur only as a subsiduary way.

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Explanation of Plate III

Galeola septentrionalis Reichb. fil.: 1. Ripe fruit, ×0.75; 2. Seed, ×25, note very slightly winged testa; 3. Longitudinal cut of fruit, ×0.75; 4. Transversal cut of fruit, ×1.5; 5-8. 184-day-old seedlings, ×3.75; 5. That with no branching; 6. That with an axillary shoot (axs) in an axil of a subtending leaf (f); 7 and 8. Those with adventitious roots (adr) under a scaly leaf (f), for 8 a seedling was cut nearly medianwise and clarified the bundle system as a result of phloroglucin-HCl reaction; 9. 140-day-old seedlings cultured in optimum atmospheres provided for each age, ×1.5; 10. The same in 492-day-old stage, transferred in a 720-ml vial shut with a sheet of thermoplastic foil ventilating ca. 7% in comparison with an uncovered open and permeating no moisture, ×1.5, note ageotropically elongated adventitious roots; 11. Another culture (1,391-day-old) distinguished with shooting downwards, ×1.5.

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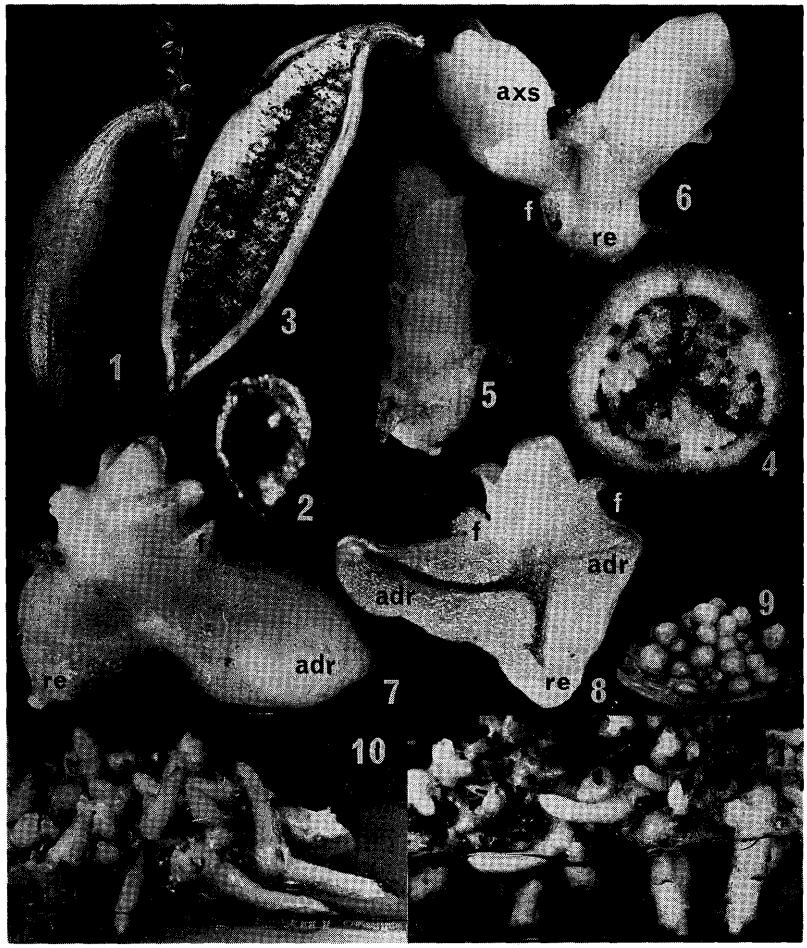
ツチアケビでは，非裂開性の果実の形状と種子発芽に必要な気体条件から，動物の食用による種子散布が想像されることがある。その果肉は食用に適した糖（又は糖アルコール）を多量に含み，特に黒変後にはその僅かな苦味も消え去る。しかるに動物にかじられた形跡は少く，種子散布が常套的に動物の食用に頼っているとは考え難い。又種子には風散布に適応した形態は認められず，滞空能力もラン科種子中では最低に類する。むしろ雨水などにより地中に運ばれて好適発芽環境に遭遇するものと推測される。



S. NAKAMURA & M. HAMADA: Seed dispersal of *Galeola septentrionalis*.